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Survey of the Marine Benthic in Fauna Collected from the United States Radioactive Waste Disposal Sites Off the Farallon Islands, California

California State Univ., Long Beach

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A total of 120 invertebrate species were collected, of which 75 species (63 percent) were polychaetes. Forty-three of these polychaete species have not previously been reported from depths greater than 1000m. A total of 1044 macroinvertebrate specimens were collected of which 54 percent were polychaetes. Only the nematods were present at all six benthic stations, but the community structure was dominated by the polychaetes Tauberia gracilis, Allia pulchra, Chaetozone setosa, and Cossura candida. Living and dead foraminifera were reported. The possible role of polychaetes in bioturbation and in the marine food chain is briefly discussed with respect to the various polychaete feeding mechanisms.

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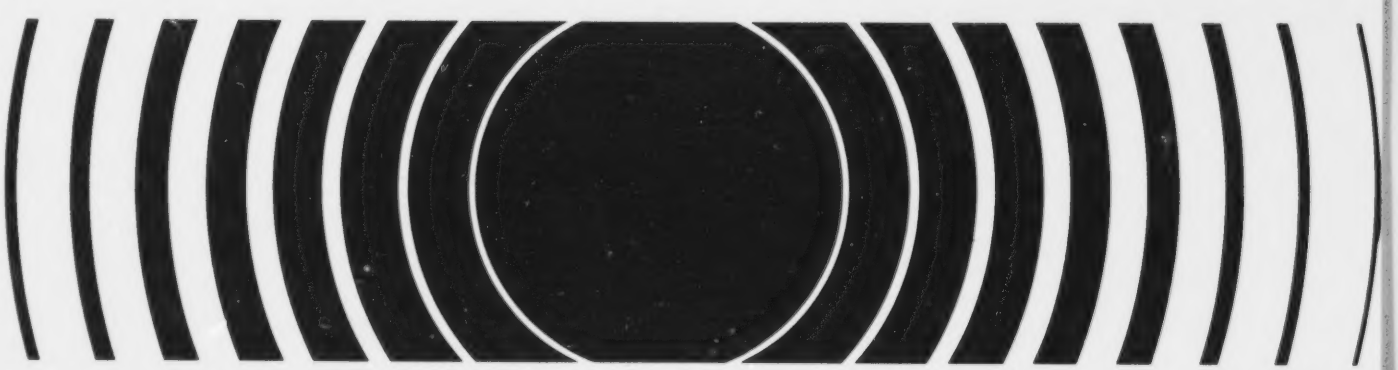

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SURVEY OF THE MARINE BENTHIC INFAUNA COLLECTED FROM THE UNITED STATES RADIOACTIVE WASTE DISPOSAL SITES OFF THE FARALLON ISLANDS, CALIFORNIA

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FOREWORD

In response to the mandate of Public Law 92-532, the Marine, Protection, Research, and Sanctuaries Act of 1972, as amended, the Environmental Protection Agency (EPA) has developed a program to promulgate regulations and criteria to control the ocean disposal of radioactive wastes. As part of that program, the EPA Office of Radiation Programs initiated feasibility studies in 1974 to learn whether present technologies could be used to determine the fate of radioactive wastes dumped in the past.

In 1974, and again in 1975, ORP obtained the services of the unmanned, tethered submersible, CURV III to conduct surveys at the Farallon Islands low-level radioactive waste dumpsite area and to determine whether current technologies could be applied toward determining the fate of radioactive waste dumped in the past. Radioactive waste packages were successfully located in this major Pacific previously-used dumpsite area, and a program of site-characterization studies was conducted to investigate (a) the biological, geochemical and physical characteristics of the area, (b) the presence and distribution of radionuclides within the area, and (c) the performance of past packaging techniques and materials.

These studies have continued to provide needed information and data on past radioactive waste disposal activities concomitant with the growing national and international interest in the possible long-term effects of this low-level waste disposal option.

A key concern of EPA in evaluating ocean disposal for low-level radioactive waste is the potential for both mobilization and biological transport of released radionuclides from a dumpsite to man. Infaunal organisms, i.e. organisms living within the sediment, may be an important element of both of these deepsea processes. The present report describes the marine infauna inhabiting the sediment in the areas of the 900 meter and 1700 meter low-level radioactive waste dumpsites near the Farallon Islands off the coast of California. This report specifically examines the presence, distribution, and abundance of the polychaetous annelid worms and the foraminifera, which are the dominant macro- and microinfauna, respectively, in the Farallon Islands dumpsite survey area.

The Agency invites all readers of this report to send any comments or suggestions to Mr. David E. Janes, Director, Analysis and Support Division, Office of Radiation Programs (ANR-461), Washington, D.C. 20460.

Glen L Sjoblom

Glen L. Sjoblom, Director
Office of Radiation Programs

ABSTRACT

Benthic biological samples were taken in 1977 from the vicinity of the Farallon Islands radioactive waste disposal sites for characterization of the infaunal macroinvertebrates and foraminifera. Six quantitative sediment samples were taken with a box core, and two non-quantitative samples were collected with an otter trawl at depths of 900m to 1700m. A sample was also taken from the surface of a radioactive waste container which was recovered from a depth of 730m for subsequent analysis at Brookhaven National Laboratory. Animals and sediment adhering to the surface of the container were scraped and preserved.

A total of 120 invertebrate species were collected, of which 75 species (63 percent) were polychaetes. Forty-three of these polychaete species have not previously been reported from depths greater than 1000m. A total of 1044 macroinvertebrate specimens were collected of which 54 percent were polychaetes. Only the nematods were present at all six benthic stations, but the community structure was dominated by the polychaetes Tauberia gracilis, Allia pulchra, Chaetozone setosa, and Cossura candida. Living and dead foraminifera were reported. Only one aberrant specimen of foraminifera was noted, which is less than generally encountered. The potential role of polychaetes in bioturbation and in the marine food chain is briefly discussed with respect to the various polychaete feeding mechanisms.

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I. INTRODUCTION

The purpose of this investigation was to identify the benthic macroinvertebrate infauna and foraminifera present in and around the vicinity of the United States Farallon Islands radioactive waste disposal sites located west of San Francisco, at depths of 900m and 1700m. Emphasis was placed on identification of the polychaetous annelids because of their abundance in terms of number of species and individuals as well as their role in the vertical and horizontal reworking of sediments. Other macroinvertebrates, the crustaceans and mollusks, were identified to the lowest possible taxon. Living as well as dead foraminifera were identified and counted. In addition, aberrant foraminifera were noted, if and whenever they occurred. Foraminifera are an important microfaunal group in deepsea sediments.

The potential role benthic macroinvertebrate fauna, especially polychaetes, could play in the movement of radionuclides, through bioturbation and food chain transport, is described. Comparisons are made of the benthic infaunal marine life between the Pacific Ocean Farallon Islands dumpsite area and the Atlantic Ocean radioactive waste disposal site centered at a depth of 2800m.

II. MATERIALS AND METHODS

Collections were made from the R/V Velero IV beginning August 31, 1977 through September 2, 1977, and October 19, 1977 through October 22, 1977. The station locations, dates, and methods of collection are given in Table 1. A bathymetric map of the dumpsite sampling areas is shown in Figure 1, and includes

both the sampling locations and the types of samples collected. A total of six benthic samples were taken with a box corer which sampled a surface area of approximately 930 cm^2 to a variable depth of 50-80 cm. The amount of material available from each box core collection for biological analysis varied depending upon the needs of other investigators. Samples from two of the six box core stations, numbers 13A and 41A, were made available for complete infaunal study. For the remaining four box core stations, about one-half of the total surface area was left for infaunal study after samples were taken for other analyses, such as radiochemistry (Schell, et al., 1979). Two otter trawls were taken to collect the larger macroepifaunal groups, such as crabs, echinoderms, and fish. Although the primary macroepibenthic faunal characterizations were done by another investigator (Carney, 1979), some of the material from these trawls was analyzed in this study and is reported herein. Each trawl was about one mile in length (Figure 1). The data reported for the trawl collection does not represent a quantitative sample.

Two 2.54 cm diameter cores were taken of the undisturbed box core sample to a depth of about 7-10 cm. The top 5 cm was then placed in a 1% rose bengal-70% ethanol solution for later foraminiferal analysis. After the ethanol solution dried, a 100 gram subsample was taken. The sediment was boiled with trisodium phosphate to break up the sediments, and then washed through a 0.127 mm sieve. The material retained on the sieve was examined under a dissecting microscope and foraminiferan specimens were removed for subsequent taxonomic identification. Scanning electron microscope pictures were taken of the dominant

foraminiferan species and are included as part of this report (Figures 6-16).

The remaining sediment core sections were washed onboard through a 0.5 mm sieve, and the material retained on the sieve was preserved with a 40% formalin solution. All biological samples were transferred to the laboratory at Long Beach from the Velero IV at its home port of San Pedro, California. In the laboratory, the samples were washed additionally through a 0.25 mm sieve to remove the formalin and remaining fine-grained sediment. The material retained on the sieve was transferred to ethanol for later sorting and identification.

Samples of macroepifaunal biological specimens collected from the trawls, and any biota and sediment which adhered to the 55-gallon, mild-steel, low-level radioactive waste disposal container retrieved for analysis were preserved in 40% formalin. Samples of this material were then processed in the laboratory as described above.

III. RESULTS

A. Invertebrates

The biological data obtained from the six benthic sampling stations and two otter trawls are summarized in Tables 2 through 5. A total of 120 identified invertebrate species are represented, of which 75 species are polychaetes, 23 are crustaceans, 16 are mollusks, 2 are echinoderms, and the remaining 4 species consisted of nematods, nemerteans, oligochaetes, and ectoprocts. A total of 1044 individual specimens were collected of which 559 specimens are polychaetes,

156 are crustaceans, 138 are mollusks, and the remaining 191 specimens are nematods, nemerteans, oligochaetes, echinoderms, and ectoprocts.

The macroinvertebrate infauna population at the six box core stations was quite diverse. None of the different groups of macroinvertebrates, except for nematods, were present at all six stations. The dominant species represented were the following polychaetes: Tauberia gracilis (Figure 2) with 68 specimens, Allia pulchra (Figure 3) with 66, Chaetozone setosa (Figure 4) with 64, and Cossura candida (Figure 5) with 59 specimens. None of these polychaete species were present at more than four stations. Tharyx sp., with 37 specimens, was found at five of the six stations. Two additional species. Lumbrineris sp. with 14 specimens and Nothria vibex with 10 specimens, were also present at four stations. Although present in only small numbers, specimens of these last two species are much larger in size than those of the more abundant species listed above.

Nematods were present within the six benthic samples; a total of 71 specimens of this phylum were taken. Because of their small size, undoubtedly many additional ones passed through the screen during the process of washing samples. Crustaceans were the second most numerous group to the polychaetes. They were dominated by the amphipods of which there were 109 specimens, representing 11 species. Pelecypods were the most numerous mollusk group present, with 111 specimens representing 12 species.

The serpulid polychaete Apomatus timsii was the only

macroscopic animal present on the surface of the radioactive waste container which was recovered. The tube of Apomatus was very similar in appearance to the unidentified serpulid polychaete present on the surface of the container recovered from the 2800m Atlantic Ocean dumpsite (see Colombo, et al., 1982, Figure 52, along lower margin of figure).

B. Foraminifera

The foraminifera were studied because they are the most common group of microfauna in deep oceanic sediments. They either possess a calcareous skeleton, such as Figures 6-14, or an arenaceous skeleton composed of sand and other debris as represented by the species in Figure 15. Because of their hard skeleton their shell may remain long after the animal has died. Foraminifera became fossilized in the geological past and they are important indicators of potential oil deposits. Foraminifera are either planktonic or benthonic inhabitants. Rose bengal is added to fresh collections and, if the animal is living at the time of collection, the protoplasm within the shell takes up the stain giving the shell a rose color. Dead specimens at the time of collection do not take up this stain. There is no way to determine the cause of death of any non-living specimens of foraminifera and furthermore they may have been dead for decades or longer at the time of collection.

A total of 4 planktonic and 77 benthonic species of forams were collected from the Farallon Islands radioactive waste disposal site (Table 3). None of the planktonic specimens were living at the time of collection and none were collected from the

sediment adhering to the surface of the recovered radioactive waste container. These planktonic species may have lived in the overlaying water or been carried into the area by currents. A total of 23 of the 77 benthonic species were alive at the time of collection (Table 5). Dead specimens were more numerous than living ones, as is the norm (Table 5). No living benthonic species were present on the container; a total of 72 specimens representing 13 species were present in the sediment adhering to the surface of the container (Table 5). There is no way of establishing any relationship between these dead forams and the low-level radioactive waste container; it is probable that they were dead long before the container was dumped into the area.

Excluding the container-recovery station, dead specimens of the planktonic species Neogloboquadrina pachyderma were present at all six box core stations; dead Neogloboquadrina dutertrei were present at five stations.

Five benthonic foram species were taken at all six box core stations and from the substrate attached to the waste container. These were Bulimina auriculata (Figure 6), Buliminella tenuata (Figure 7), Chilostomella oolina, Epistominella pacifica (Figure 8), and Uvigerina peregrina (Figure 9). A total of 70 living specimens of Bulimina auriculata were collected, followed by Uvigerina peregrina with 35. No aberrant living specimen was noted, and only one dead specimen of Epistominella pacifica was abnormal, which is not considered significant.

Other benthonic foraminifera, for which photomicrographs are provided include Bulimina striata mexicana (Figure 10) taken from five of the six box core stations, Chilostomellina fimbriata

(Figure 11) taken from four stations, Cribrostomoides subglobosum (Figure 12) taken from two stations, Globobulimina pacifica (Figure 13) taken from five stations, Planulina wuellerstorfi (Figure 14) taken from two stations, Reophax horridus (Figure 15), an arenaceous species, taken from two stations, and Uvigerina hispida (Figure 16) taken from four stations.

IV. DISCUSSION AND CONCLUSIONS

The polychaetous annelids were the dominant macroinvertebrate group collected from the Farallon Islands radioactive waste disposal sites--about 63 percent of the species and 54 percent of the total number of specimens collected belonged to this group. These figures are quite similar to the 45 percent of the species and 49 percent of the specimens, respectively, collected and identified at the 2800m Atlantic Ocean radioactive waste dumpsite (Reish, 1983). Knox (1977) stated that, in general, polychaete species comprise over 40 percent of the soft bottom macroinvertebrate benthic communities regardless of depth. Jumars and Hessler (1976) reported that polychaetes constituted about 49 percent of the macroin vertebrates collected from the Aleutian Trench at depths of 7000-7500m. The numbers of polychaete specimens averaged 58 percent of the macroinvertebrate population at depths from 1000 to 5000m in one large northwestern Atlantic Ocean study (Hartman and Fauchald, 1971). The number of species and numerical abundance of polychaete populations at the two radioactive waste dumpsite areas fall within what has been observed elsewhere in ocean depths.

One striking difference between the polychaetes collected from the Farallon Islands area and the 2800m Atlantic Ocean dumpsite was the size of the animals - the Pacific Ocean specimens were comparatively large while the 2800m Atlantic Ocean polychaetes were small (Reish, 1983). The sea mouse, Aphrodita japonica, was the largest Pacific polychaete species encountered. Four specimens were collected by otter trawl and weighed 4.0, 9.75, 12.6, and 19.9 grams (wet weight), respectively. While weights are unknown, much larger specimens have been observed by the author in the polychaete collections at the Allan Hancock Foundation, University of Southern California. Other large species found at the Farallon Islands dumpsite area included Aglaophamus paucilamellata, Ampharete arctica, Anobothrus gracilis, Laetomonice pellucida, Maldane sarsi, Nothria vibex, Rhodine bitorquata, and Terebellides nr. stroemi. Some of these species build tubes of sediment which will measure up to 1.0 cm in diameter and potentially provide significant bioturbation of the sediment if present in significant numbers. Of the above eight species, Maldane sarsi, was found in proportionally large numbers at Stations 13A (17 specimens) and 41A (8 specimens), the two stations where the complete box core was washed for biological material. Rhodine bitorquata was found in proportionally very large numbers (32 specimens) at Station 13A (Table 4).

The population of invertebrates in the Farallon Islands dumpsite area ranged from 280 to 4124 specimens/m^2 with an average of 1770 specimens/m^2 or 1643/m^2 if the nematods are excluded. Nematods are considered as meiofauna and are not generally considered as macroinvertebrates. These population figures are

about four times higher than those measured at the 2800m Atlantic Ocean dumpsite (Reish, 1983). While biomass was not measured for either collection, the corresponding amount of biological material would be at least one, or possibly two orders of magnitude greater for the Farallon Islands radioactive waste disposal site area. It was readily apparent that a greater amount of biomass was present in the benthos off the Farallon Islands radioactive waste dumpsite since the sediment was composed largely of fecal pellets. No fecal pellets were noted in the sieved sediment collected at the Atlantic Ocean 2800m dumpsite (Reish, 1983).

Most of the polychaetes present in these samples feed on sediment particles which are covered with organic coatings. Detrital feeders such as Anobothrus trilobatus utilize appendages to bring sediment to their mouths. Predominant polychaetes are illustrated in Figures 2-5. They engulf the sediment, digest the organic material present, and eliminate the undigested portion out their anus. These species play a significant role in the reworking of the sediments, and this action accounts for the presence of the many fecal pellets in the sediment. Since the sedimentation rate is very slow at these depths at 2-6 cm/1000 yr on the continental slope (Dayal, et al., 1979), and since a thin mucous film is secreted over these pellets during elimination, the individual pellet retains its identity. Other species, such as Maldane sarsi, not only engulf sediment for food but also construct tubes from this sediment. Such tubes can retain their shape long after the worm has died. A few species from the Farallon Islands dumpsite area are carnivorous; we can include

such species as Aphrodita japonica and Lumbrineris sp. within this group. They probably feed upon nematods, polychaetes, and smaller crustaceans (Fauchald and Jumars, 1979).

The role of polychaetes in the deep sea marine food chain has been little studied. However, on the basis of the morphology of these species, we can determine with some certainty the trophic position of the polychaetes. As stated above, most of these species are either detrital or sediment feeders with a few carnivores present. As indicated by the large amount of fecal material present in the sediments, bioturbation in the Farallon Islands dumpsite is very extensive. Dayal, et al., (1979) reported the sediment deposition rate to be on the order of 190-1140 cm^2/1000 years. If radioactive material is leaking from the containers, then it is possible that some of this material may be buried by bioturbation or brought back to the surface at a later date by the same bioturbation process. Because of the presence of some large detrital feeding and carnivorous species of polychaetes, it is possible that radioactive material could be transferred upward from sediment to a detrital feeding polychaete to a fish, on the one hand, or from the detrital feeding polychaete to a carnivorous polychaete to a fish, on the other hand. It would be very useful to have an invertebrate zoologist examine the entire contents of the digestive tract of any fish specimen taken in the future at this dumpsite to determine feeding habits. Such data would give us a clearer understanding of deep sea food chain beginnings at the lower trophic levels.

The list of polychaetous annelid species previously known off the California coast in depths greater than 1000m is

summarized in Table 6. This depth limit was selected to coincide and provide a comparison with a similar depth tabulation developed for the Atlantic 2800m dumpsite (Reish, 1983) which had been chosen arbitrarily for that study. Nearly twice as many species of polychaetes have been reported from the northwestern Atlantic Ocean than the northeastern Pacific Ocean (316 to 169). This difference is more than likely the result of more extensive studies made at these depths in the Atlantic Ocean (Hartman, 1965; Hartman and Fauchald, 1971) than the Pacific Ocean, and, furthermore, the geographical area studied extended from New England to Bermuda in the Atlantic compared to California in the Pacific. Of the 169 different Pacific polychaete species which have been previously reported from depths greater than 1000m, 24 of these species are reported herein (Table 4). The remaining 43 species collected which have not previously been reported from depths exceeding 1000m, are indicated with a single asterisk in Table 4 (Hartman, 1968, 1969; Fauchald and Hancock, 1982). Therefore, from the present study alone, 43 species of polychaetes can be added to the list of those recorded below a depth of 1000m (Table 4). The six undescribed species of polychaetes (Asabellides sp., Eumida sp., Eunereis sp., Mugga sp., Neosabellides sp., and Paiwa sp.) collected near the Farallon Islands were also part of a collection of over 100 new polychaete species taken a year or two earlier during the course of the Outer Continental Shelf baseline study by the Bureau of Land Management (BLM). The new species have not been described as of 1983. Several specimens of the serpulid polychaete, Apomatus

timsii, were found only on the radioactive waste container which was raised to the surface. This species was previously reported only from a depth of 110m off Monterey, California.

Only four species of planktonic foraminifera, all dead, were taken from the Farallon Islands site. No living specimens of forams were taken from the surface of the retrieved radioactive waste disposal container which is probably not significant since the number of dead specimens always greatly exceeds living ones. The species composition and population of foraminifera is considered to be normal for this depth and geographical region (Dr. Paul Fritts, personal communication).

Since the Farallon Islands radioactive waste disposal sites are in an area of high biological infaunal activity, as represented by the high concentration of fecal pellets in the sediments, this locality should be avoided as a potential future disposal area for low-level radioactive waste materials because of the greater potential for these materials to move upward in the food chain.

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My interest and involvement in characterizing benthic faunal composition in the vicinity of the United States radioactive waste disposal sites and the possible role of benthic organisms in the movement and reworking of sediment (bioturbation) began in 1974 through contacts with Robert S. Dyer of the Office of Radiation Programs, U.S. Environmental Protection Agency, and Sam Kelly, of Interstate Electronics Corporation, a contractor to EPA. I would again like to express my thanks to these two scientists for involving me in this problem which is unique to the twentieth century.

Two expeditions were made to the Farallon Islands locality in 1977. Randy McGlade participated in my behalf on both of these expeditions. I wish to express my thanks to him for doing a fine job of collecting and preserving the material.

I would like to thank the following biologists for identifying some of the organisms collected. These include: Paul Fritts, California State University, Long Beach (Foraminifera); Bruce Benedict, (Crustaceans); Charles A. Phillips, California State University, Long Beach (Mollusks); Sue Williams, University of Southern California (Polychaetes); and Karen Green, California State University, Long Beach (Polychaetes).

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Table 1

Station Locations, Farallon Islands Radioactive Waste Disposal Site, 1977

Station Number	Date	Latitude (°N)	Longitude (°W)	Sampling Device	Depth (Meters)
13A	8-31-77	37°38.1'	123°08'	Box Corer*	1025
2A	8-31-77	37°38.8'	123°07.1'	Box Corer	865
47	9-1-77	37°38.3'	123°14'	Box Corer	1400
39	9-1-77	37°38'	123°17'	Box Corer	1525
41A	9-1-77	37°38'	123°20.7'	Box Corer*	2250
48	9-1-77	37°36.6'	123°12.7'	Box Corer	1170
Near 45	9-2-77	37°34'-37°35.5'	123°13'-123°16'	Otter Trawl	1150-1520
South of 15	10-19-77	37°31.7'-37°32.8'	123°05.8'-123°04.7'	Otter Trawl	360-700
Near Station 8	10-22-77	37°38.1'	123°07.6'	Waste Package Retrieval. (Sampled mud adhering to surface)	730

*Complete sample washed for biological material.

Note: Center of 900 meter dumpsite area: 37°38'N, 123°08'W

Center of 1700 meter dumpsite area: 37°37'N, 123°17'W

Table 2

Systematic List of the Macroinvertebrates Collected
from the Farallon Islands Radioactive Waste Disposal Site, 1977

Phylum Nematoda
nematodes, unidentified

Phylum Nemertea
nemerteans, unidentified

Phylum Annelida
Class Hirudinea
leech, unidentified

Class Oligochaeta
oligochaetes, unidentified

Class Polychaeta
Acesta lopezi lopezi
Acesta nr. *assimilis*
Acesta sp.
Aglaophamus paucilamellata
Allia pulchra
Allia ramosa
Allia sp.
Ampharete arctica
ampharetid, unidentified genus
ampharetid, juvenile
Anobothrus gracilis
Anobothrus trilobatus
Aphrodita japonica
Apomatus timsii
Asabellides sp.
Chaetozone setosa
Chone ecaudata
Cossura candida
Cossura sp.
Dorvillea batica
Drilonereis falcata
?*Euchone vilifera*
Euclymene sp.
Eucranta anoculata
Eumida tubiformis
Eumida sp.
Eunereis sp.
Eunice sp.
Fabrisabella vasculosa
Fauveliopsis rugosa
Glycera capitata
Glyphanostomium pallescens

Table 2 (continued)

Goniada brunnea
Harmothoe crassicirrata
Intasbella caeca
Jasmineira gracilis
Laetomonice pellucida
Lanassa gracilis
Lumbrineris longensis
Lumbrineris mininae
Lumbrineris sp.
Maldane sarsi
Maldane sp.
Mugga sp.
Myriochele gracilis
Neanthes sp.
Nereis anoculopsis
Nephtys cornuta franciscana
Neoamphitrite robusta
Neomediomastus glabrus
Neosabellides sp.
Nothria vibex
Notomastus abyssalis
Notomastus precocis
Notomastus sp.
Ophelia sp.
oweniid, fragment
Paiwa sp.
Pherusa papillata
Phylo nudus
Pirakia brunnea
Prionospio steenstrupi
Praxillella affinis pacifica
Pseudoeurythoe abyssalis
Rhodine bitorquata
Scalibregma inflatum
Sphaerodoropsis nr. *oculata*
Spiochaetopterus costarum
Spiophanes fimbriata
Sthenelepis areolata
Subadyte mexicana
Tauberia gracilis
Terebellides nr. *stroemi*
Tharyx sp.
Typosyllis aciculata orientalis

Table 2 (continued)

Phylum Mollusca
Class Pelecypoda
Cardiomya sp.
Delectopecten sp.
Leptonidae sp. A
Leptonidae sp. B
Lucinidae
?Lucinidae
Macoma sp. A
Macoma sp. B
Nucula sp.
Nuculanidae
?*Yoldia montereyensis*
Yoldia sp.

Class Gastropoda
Crystallophrisson sp.
Scissurella crispata
Turridae

Class Scaphopoda
?*Dentalium (Laeuidentalium) rectius*

Phylum Arthropoda
Class Crustacea
Order Ostracoda
Cylindrolebendinae, unidentified

Order Isopoda
Lironeca vulgaris
isopoda, unidentified

Order Tanaidacea
Leptognathia sp.

Order Cumacea
Campylaspis sp.
Eudonella pacifica
Leucon ?armatus
Leucon subnasica
Leucon sulenacica
Leucon sp.

Order Amphipoda
Ampelisca posetica
Ampelisca sp.
Heterophoxus oculatus
Hippomedon sp.
Lilgeborgia sp.
Lysianissidae sp.
Nicippe tumida
Photis sp.
?*Protomedia* sp.
Synchelidia sp.
gammarids, unidentified

Order Mysidacea
mysid, unidentified

Order Decapoda
decapod, unidentified

Phylum Echinodermata
Class Ophiuroidea
brittlestars, unidentified

Class Holothuroidea
sea cucumbers, unidentified

Phylum Ectoprocta
ectoprocts, unidentified

Table 3

Systematic List of the Foraminifera Collected from

the Farallon Islands Radioactive Waste Disposal Site, 1977

Adercostrema glomerata? (Brady)
Alveolophragmium scitulum (Brady)
Brizalina pacifica Cushman & McCulloch
Brizalina peirsonae (Uchio)
Brizalina spissa (Cushman)
Brizalina subadvena Cushman
Brizalina subadvena serrata (Natland)
Bulimina auriculata Bailey
Bulimina barbata Cushman
Bulimina hoeglundi (Uchio)
Bulimina cf. B. pupoides d'Orbigny
Bulimina pyrula spinescens Brady
Bulimina striata mexicana Cushman
Buliminella tenuata Cushman
Caribeanella sp.
Cassidulina californica Cushman & Hughes
Cassidulina delicata Cushman
Cassidulina lomitensis Galloway & Wissler
Cassidulina subcarinata Uchio
Cassidulinoides parkerianus (Brady)
Chilostomella oolina Schwager
Chilostomellina fimbriata Cushman
Cibicides fletcheri? Galloway & Wissler
Cibicides mckannai Galloway & Wissler
Cribrostomoides sp.
Cribrostomoides subglobosum (Sars)
Cribrostomoides veleronis (Cushman & McCulloch)
Dentalina baggi Galloway & Wissler
Elphidium cf. E. advenum (Cushman)
Epistominella pacifica (Cushman)
Epistominella smithi (R.E. & K.C. Stewart)
Eponides subtener Galloway & Wissler
Fissurina bradii Silvestri
Fursenkoina bramlettei (Galloway & Morrey)
Fursenkoina rotundata (Parr)
Globigerina bulloides (d'Orbigny)
Globobulimina pacifica Cushman
Gyroidina altiformis Cushman
Gyroidina altiformis acuta Boomgaart
Gyroidina gemma Bandy
Gyroidina neosoldanii Brotzen
Haplophragmoides cf. H. tenuum Cushman
Karreriella apicularis (Cushman)
Lagena amphora Reuss
Loxostomum pseudobeyrichi (Cushman)

Table 3 (continued)

Martinotiella primaeva (Cushman)
Neogloboquadrina dutertrei (d'Orbigny)
Neogloboquadrina pachyderma (d'Orbigny)
Nonionella basiloba Cushman & McCulloch
Nonionella miocenica Cushman
Nonionella miocenica stella Cushman & Moyer
Nouria harrisii Heron-Allen and Earland
Oridorsalis cf. O. tener (Brady)
Oridorsalis tener (Brady)
Planulina sp.
Planulina wuellerstorfi (Schwager)
Pleurostomella sp.
Pullenia malkinae Coryell & Mossman
Pyrgo cf. P. murrhyna (Schwager)
Recurvoides sp.
Reophax curtis Cushman
Reophax dentalinaformis Brady
Reophax horridus Cushman
Reophax scorpiurus Montfort
Reophax ? sp.
Reophax subfusiformis Earland
Rhizammina sp.
Saccamina longicollis (Weisner)
Thalmannammina ? sp.
Tritaxis bullata (Höglund)
Tritaxis ? sp.
Trochammina inflata? (Montagu)
Trochammina ? sp.
Turborotalia scitula (Brady)
Uvigerina auberiana d'Orbigny
Uvigerina curticosta Cushman
Uvigerina hispida Schwager
Uvigerina juncea Cushman & Todd
Uvigerina peregrina Cushman
Uvigerina peregrina dirupta Todd
Uvigerina ? sp.

Table 4

Species and Number of Macroinvertebrates Collected from the

Farallon Islands Radioactive Waste Disposal Sites, 1977

(*Polychaetes not previously reported from depths exceeding 1000 meters)
(**Polychaetes collected from depths <1000 meters in present study and not previously reported from depths >1000 meters)

Species/Station Number:	13A	2A	47	39	41A	48	Otter Trawl 9-2-77	Otter Trawl 10-19-77	Barrel	Total
Nematoda, unidentified	23	6	15	4	20	3				71
Nemertea, unidentified	1	2				4	1			8
Annelida - Hirudinea, unidentified							1			1
Annelida - Oligochaeta, unidentified	1	102								103
Annelida - Polychaeta										
Acesta lopezi lopezi			1		1	1				3
* *Acesta* nr. *assimilis*						2				2
* *Acesta* sp.	4			1						5
* *Aglaophamus paucilamellata*						2				2
* *Allia pulchra*					55	12				67
Allia ramosa					1					1
* *Allia* sp.						10				10
Ampharete arctica			1							1
* ampharetid, unidentified					1					1
* ampharetid, juvenile				1						1
* *Anobothrus gracilis*						1				1
* *Anobothrus trilobatus*				2		3				5
* *Aphrodita japonica*							4			4
** *Apomatus timsii*									7	7
* *Asabellides* sp.						4				4
* *Chaetozone setosa*	6		1	2		55				64
* *Chone ecaudata*						6				6
Cossura candida		36			1	22				59
* *Cossura* sp.	1									1
* *Dorvillea batica*						1			1	2

Table 4 (continued)

Species/Station Number:	13A	2A	47	39	41A	48	Otter Trawl 9-2-77	Otter Trawl 10-19-77	Barrel	Total
Drilonereis falcata				1						1
*?*Euchone vilifera*					1					1
* *Euclymene* sp.	13					1				14
** *Eucranta anoculata*		1								1
Eumida tubiformis								1		1
** *Eumida* sp.								1		1
** *Eunereis* sp.								1		1
* *Eunice* sp.							1			1
* *Fabrisabella vasculosa*						1				1
* *Fauveliopsis rugosa*				1						1
* *Glycera capitata*					1					1
* *Glyphanostomium pallescens*			1	2		5				8
Goniada brunnea			1							1
** *Harmothoe crassicirrata*								1		1
Intoshella caeca							1			1
* *Jasmineira gracilis*						1				1
Laetomonice pellucida							2			2
* *Lanassa gracilis*						6				6
Lumbrineris longensis							2			2
* *Lumbrineris mininae*					1					1
* *Lumbrineris* sp.	1		2		3	8				14
* *Maldane sarsi*	17				8					25
* *Maldane* sp.			1							1
* *Mugga* sp.			1			5				6
Myriochele gracilis	1									1
* *Neanthes* sp.							1			1
Nereis anoculis							1		1	2
* *Nephtys cornuta franciscana*	3					3				6
** *Neoamphitrite robusta*								2		2
Neomediomastus glabrus				1		9				10

Table 4 (continued)

Species/Station Number:	13A	2A	47	39	41A	48	Otter Trawl 9-2-77	Otter Trawl 10-19-77	Barrel	Total
*Neosabellides sp.			5							5
*Nothria vibex		1	1		1	4	3			10
*Notomastus abyssalis						2				2
Notomastus precocis					1					1
*Notomastus sp.				1						1
**Ophelia sp.		1								1
*oweniid, fragment					1					1
*Paiwa sp.						2				2
Pherusa papillata							1			1
Phylo nudus							10			10
*Pirakia brunnea						2				2
Prionospio steenstrupi						1				1
*Praxillella a. pacifica	2				2					4
*Pseudoeurythoe abyssalis					1					1
Rhodine bitorquata	32					1				33
Scalibregma inflatum		1								1
*Sphaerodoropsis nr. oculata						2				2
Spiophanes fimbriata					1	1				2
Stenelepis areolata						1	4			5
*Subadyte mexicana						3				3
Tauberia gracilis	1		2		4	61				68
Telepsavus costarum					1					1
Terebellides stroemi	2	1				5				8
*Tharyx sp.	13	1	2	3		18				37
**Typosyllis a. orientalis								2		2
Mollusca - Pelecypoda										
Cardiomya sp.						1				1
Delectopecten sp.									2	2
Leptonidae sp. A				1	1					2

Table 4 (continued)

Species/Station Number:	13A	2A	47	39	41A	48	Otter Trawl 9-2-77	Otter Trawl 10-19-77	Barrel	Total
Leptonidae sp. B	4	31				1				36
Lucinidae						3				3
?Lucinidae	1									1
Macoma sp. A		16								16
Macoma sp. B		8								8
Nucula sp.	1	5				2				8
Nuculanidae		3								3
?Yoldia montereyensis	1	23					1			25
Yoldia sp.		6								6
Mollusca - Gastropoda										
Crystallophrisson sp.				1	3					4
Scissurella crispata						1				1
Turridae		2								2
Mollusca - Scaphopoda										
?Dentalium (L.) rectius		20								20
Arthropoda - Ostracoda										
Cylindrolebendinae		1								1
Arthropoda - Isopoda										
Lironeca vulgaris							1			1
isopoda, unidentified						1				1
Arthropoda - Tanaidacea										
Leptognathia sp.					2					2
Arthropoda - Cumacea										
Campylaspis sp.		2								2
Eudonella pacifica		7				1				8

Table 4 (continued)

Species/Station Number:	13A	2A	47	39	41A	48	Otter Trawl 9-2-77	Otter Trawl 10-19-77	Barrel	Total
Leucon ? armatus		1								1
Leucon subnasica						1				1
Leucon sulenacica		25								25
Leucon sp.	2									2
Arthropoda - Amphipoda										
Ampelisca posetica		8								8
Ampelisca sp.		5							2	7
Heterophoxus oculatus		13		1	2					16
Hippomedon sp.	1									1
Lilgeborgia sp.									1	1
Lysianissidae sp.		42				1			10	53
Nicippe tumida	1	10				1				12
Photis sp.				3		1				4
?Protomedia sp.			2						1	3
Synchelidia sp.		2								2
gammarids						2				2
Arthropoda - Mysidacea										
mysid, unidentified				1						1
Arthropoda - Decapoda										
decapod, unidentified						1				1
Echinodermata - Ophiuroidea										
brittlestars			1	1		1	1			4
Echinodermata - Holothuroidea										
sea cucumbers		1			2					3
Ectoprocta										
ectoprocts									+	+
Number of Species	23	31	15	20	24	50	16	6	9	194
Number of Specimens	132	383	36	26	115	295	35	8	25+	1044+

Table 5

Species and Number of Specimens of Foraminifera Collected from the Farallon Islands Radioactive Waste Disposal Site, 1977

Species	Planktonic / Benthonic	STATION NUMBER 2A L*	2A D*	13A L	13A D	Barrel L	Barrel D	39 L	39 D	41A L	41A D	47 L	47 D	48 L	48 D
Adercotrema glomerata?	B								5						
Alveolophragmium scitulum	B										1				
Brizalina pacifica	B		1												
Brizalina peirsonae	B				1										
Brizalina spissa	B		2	2	6		3		1				25		
Brizalina subadvena	B			1											
Brizalina subadvena serrata	B			1	1		1								
Bulimina auriculata	B	19	34	36	51		21	1	26		1		7	14	38
Bulimina barbata	B										2				
Bulimina hoeglundi	B										1				
Bulimina cf. B. pupoides	B										1				
Bulimina pyrula spinescens	B			1	2				1				2		2
Bulimina striata mexicana	B			1	8		1		5				12		4
Buliminella tenuata	B	1		5	9		5	1	14	1	29		11		15
Caribeanella sp.	B												1		
Cassidulina californica	B							1	1						
Cassidulina delicata	B								1		1		3		1
Cassidulina lomitensis	B												1		
Cassidulina subcarinata	B								49						
Cassidulinoides parkerianus	B								6		1		3		
Chilostomella oolina	B		1	3	1		1	1	20	1	12	3	12	5	17
Chilostomellina fimbriata	B								1		2		18		3

Table 5 (continued)

Species	Planktonic / Benthonic	STATION NUMBER 2A L*	2A D*	13A L	13A D	Barrel L	Barrel D	39 L	39 D	41A L	41A D	47 L	47 D	48 L	48 D
Cibicides fletcheri?	B												1		
Cibicides mckannai	B										1				
Cribrostomoides sp.	B										9				
Cribrostomoides subglobosum	B			16	21		2								
Cribrostomoides veleronis	B								38				6	3	14
Dentalina baggi	B														1
Elphidium cf. E. advenum	B								3						
Epistominella pacifica	B	9	59	12	81		19		3		27	1	185		150
Epistominella smithi	B												13		3
Eponides subtener	B							1	2		2		2		
Fissurina bradii	B								2						
Fursenkoina bramlettei	B							4	1						1
Fursenkoina rotundata	B								2						
Globigerina bulloides	P		11						38		2		3		
Globobulimina pacifica	B			5	5			2	1		4	6	10	3	1
Gyroidina altiformis	B														1
Gyroidina altiformis acuta	B										1				
Gyroidina gemma	B														1
Gyroidina neosoldanii	B										8				
Haplophragmoides cf. H. tenuum	B										2				
Karreriella apicularis	B								1				1		
Lagena amphora	B										1				
Loxostomum pseudobeyrichi	B												1		
Martinotiella primaeva	B								10		6		3		
Neogloboquadrina dutertrei	P		2		1				9		2				2
Neogloboquadrina pachyderma	P		11		13				8		26		9		1
Nonionella basiloba	B		1												
Nonionella miocenica	B										4				

Table 5 (continued)

Species	Planktonic / Benthonic	STATION NUMBER 2A L*	2A D*	13A L	13A D	Barrel L	Barrel D	39 L	39 D	41A L	41A D	47 L	47 D	48 L	48 D
Nonionella miocenica stella	B		1				1								
Nouria harrisii	B	1													
Oridorsalis cf. O. tener	B										5				
Oridorsalis tener	B								3				1		
Planulina sp.	B								1						
Planulina wuellerstorfi	B										1		2		
Pleurostomella sp.	B				4		2								
Pullenia malkinae	B										3				
Pyrgo cf. P. murrhyna	B														1
Recurvoides sp.	B	1	3		3				5			1	3		
Reophax curtis	B										2				
Reophax dentalinaformis	B				1				3						2
Reophax horridus	B	1		1	2										
Reophax scorpiurus	B								1						
Reophax ? sp.	B			1							3				
Reophax subfusiformis	B				2										
Rhizammina sp.	B								1		1				
Saccamina longicollis	B								2						
Thalmannammina ? sp.	B														6
Tritaxis bullata	B													1	10
Tritaxis ? sp.	B				1		1		3						
Trochammina inflata?	B								1						
Trochammina ? sp.	B						1								
Turborotalia scitula	P								1						
Uvigerina auberiana	B								53				2		
Uvigerina curticosta	B								2						
Uvigerina hispida	B								8		14		2		13
Uvigerina juncea	B		1												2
Uvigerina peregrina	B	24	16	10	50		14		26		1		46	1	23

Table 5 (continued)

Species	Planktonic / Benthonic	STATION NUMBER 2A L*	2A D*	13A L	13A D	Barrel L	Barrel D	39 L	39 D	41A L	41A D	47 L	47 D	48 L	48 D
Uvigerina peregrina dirupta	B	1							4						
Uvigerina ? sp.	B								1		1				
TOTAL PLANKTONIC SPECIMENS:			24		14				56		30		12		3
TOTAL BENTHONIC SPECIMENS:		57	118	97	248		72	11	307	2	147	11	373	27	309
Number of Living Species			8		16		0		7		2		4		6

*L and D denote living and dead specimens

Table 6

List of Polychaetous Annelids Reported Offshore from California in Depths Greater than 1000 Meters

Family Aphroditidae
- *Aphrodita longipalpa* Essenberg
- *Aphrodita parva* Moore
- *Laetmonice producta wyvillei* McIntosh

Family Polynoidae
- *Admetella hastigerens* Chamberlin
- *Antinoella anoculata* (Moore)
- *Bathymoorea renotubulata* (Moore)
- *Eunoe barbata* Moore
- *Gattyana brunnea* Hartman
- *Harmothoe forcipata* (Marenzeller)
- *Harmothoe fragilis* (Moore)
- *Harmothoe scriptoria* Moore
- *Harmothoe tenebricosa* Moore
- *Hesperonoe laevis* Hartman
- *Intoshella caeca* (Moore)
- *Lagisca lamellifera* (Marenzeller)
- *Lagisca multisetosa* Moore
- *Lagisca yokohamiensis* McIntosh
- *Lepidasthenia interrupta* (Marenzeller)
- *Macellicephala? aciculata* (Moore)
- *Macellicephala remigata* (Moore)
- *?Polynoe filamentosa* Moore
- *Panthalis pacifica* Treadwell

Family Sigalionidae
- *Leanira alba* Moore
- *Leanira calcis* Hartman
- *Pholoe glabra* Hartman
- *Sthenelais verruculosa* Johnson
- *Sthenelepis areolata* (McIntosh)

Family Pisionidae
- *Pisione remota* (Southern)

Family Amphinomidae
- *Pseudeurythoe ambigua* (Monro)

Family Euphrosinidae
- *Euphrosine paucibranchiata* Hartman

Family Phyllodocidae
- *Anaitides groenlandica* (Oersted)
- *Anaitides madeirensis* (Langerhans)
- *Anaitides multiseriata* Rioja
- *Eulalia bilineata* (Johnston)

Family Phyllodocidae (continued)
Eumida bifoliata (Moore)
Eumida tubiformis (Moore)
Genetyllis castanea (Marenzeller)
Notophyllum imbricatum Moore
Paranaitis polynoides (Moore)
Phyllodoce sp.

Family Alciopidae
Alciopina tenuis (Apstein)

Family Lacydonidae
Paralacydonia paradoxa Fauvel

Family Tomopteridae
Tomopteris septentrionalis Steenstrup

Family Pilargidae
Ancistrosyllis breviceps Hartman
Ancistrosyllis hamata (Hartman)

Family Syllidae
Exogonella brunnea Hartman
Pionosyllis gigantea Moore
Typosyllis alternata (Moore)

Family Nereidae
Ceratocephale loveni pacifica Hartman
Ceratonereis paucidentata (Moore)
Eunereis caeca Hartman
Nereis anoculis Hartman

Family Nephtyidae
Nephtys punctata Hartman
Nephtys rickettsi Hartman
Nephtys schmitti Hartman
Nephtys squamosa Ehlers

Family Sphaerodoridae
Sphaerodoridium biserialis (Berkeley and Berkeley)
Sphaerodoridium sphaerulifer (Moore)
Sphaerodorum brevicapitis Moore
Sphaerodorum papillifer Moore

Family Glyceridae
Glycera americana Leidy
Glycera branchiopoda Moore
Glycera capitata Oersted
Glycera oxycephala Ehlers
Glycera tesselata Grube

Family Goniadidae
Goniada annulata Moore
Goniada brunnea Treadwell

Family Onuphidae
Diopatra tridentata Hartman
Hyalinoecia tubicola stricta Moore
Nothria hiatidentata Moore
Nothria pallida Moore
Onuphis nebulosa Moore

Family Eunicidae
Marphysa disjuncta Hartman
Marphysa stylobranchiata Moore

Family Lumbrineridae
Lumbrineris bicirrata Treadwell
Lumbrineris californiensis Hartman
Lumbrineris cruzensis Hartman
Lumbrineris index Moore
Lumbrineris inflata Moore
Lumbrineris longensis Hartman
Lumbrineris moorei Hartman
Lumbrineris tetraura (Schmarda)
Ninoe fusca Moore
Ninoe gemmea Moore

Family Arabellidae
Drilonereis falcata Moore
Notocirrus californiensis Hartman

Family Dorvilleidae
Dorvillea articulata (Hartman)

Family Orbiniidae
Califia calida Hartman
Naineris uncinata Hartman
Phylo nudus (Moore)
Scoloplos acmeceps profundus Hartman

Family Paraonidae
Acesta lopezi lopezi (Berkeley and Berkeley)
Acesta lopezi rubra (Hartman)
Aedicira antennata (Annekova)
Aedicira ramosa (Annekova)
Aricidea neosuecica (Hartman)
Aricidea suecica (Eliason)
Cirrophorus aciculatus (Hartman)
Cirrophorus furcatus (Hartman)
Tauberia gracilis (Tauber)
Tauberia oculata (Hartman)

Family Apistobranchidae
Apistobranchus ornatus (Hartman)

Table 6 (continued)

Family Spionidae
Laonice foliata (Moore)
Laonice sacculata (Moore)
Nerinides pigmentata (Reish)
Polydora spongicola (Berkeley and Berkeley)
Prionospio cirrifera Wiren
Prionospio pinnata Ehlers
Prionospio steenstrupi Malmgren
Spiophanes anoculata Hartman
Spiophanes bombyx (Claparede)
Spiophanes fimbriata Moore
Spiophanes pallidus Hartman

Family Magelonidae
Magelona pacifica Monro

Family Disomidae
Disoma franciscanum Hartman

Family Chaetopteridae
Phyllochaetopterus limnicolus Hartman
Telepsavus costarum Claparede

Family Cirratulidae
Caulleriella gracilis Hartman
Chaetozone armata Hartman
Chaetozone gracilis (Moore)
Chaetozone spinosa Moore
Cirratulus cirratus (Muller)
Tharyx monilaris Hartman
Tharyx tesselata Hartman

Family Cossuridae
Cossura candida Hartman

Family Flabelligeridae
Brada villosa (Rathke)
Fauveliopsis glabra (Hartman)
Ilyphagus ilyvestis Hartman
Pherusa papillata (Johnson)

Family Scalibregmidae
Asclerocheilus californicus Hartman
Oncoscolex pacificus (Moore)
Scalibregma inflatum Rathke

Family Opheliidae
Ammotrypane aulogaster Rathke
Ammotrypane pallida Hartman
Polyophthalmus translucens Hartman
Travisia brevis Moore
Travisia foetida Hartman

Family Capitellidae
Neoheteromastus lineus Hartman
Neomediomastus glabrus (Hartman)
Notomastus precocis Hartman

Family Maldanidae
Asychis nr. *gotoi* (Izuka)
Asychis lacera (Moore)
Clymenopsis californiensis Hartman
Euclymene reticulata Moore
Lumbriclymene lineus Hartman
Maldane glebifex Grube
Nicomache lumbricalis (Fabricius)
Notoproctus pacificus (Moore)
Praxillella trifila Hartman
Praxillura maculata Moore
Rhodine bitorquata Moore

Family Oweniidae
Myriochele gracilis Hartman
Myriochele pygidialis Hartman

Family Ampharetidae
Amage arieticornuta Moore
Amelinna abyssalis Hartman
Amelinna armipotens (Moore)
Ampharete acutifrons (Grube)
Ampharete arctica Malmgren
Amphicteis scaphobranchiata Moore
Lysippe annectens Moore
Melinna heterodonta Moore
Melinnampharete gracilis Hartman
Melinnexis moorei Hartman

Family Terebellidae
Pista disjuncta Moore
Pista fasciata (Grube)

Family Trichobranchidae
Terebellides ehlersi McIntosh
Terebellides stroemi Sars

Family Sabellidae
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Potamethus mucronatus (Moore)

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5. Anterior end of the polychaete Cossura candida, redrawn after Hartman, 1969
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7. Benthonic foraminiferan Buliminella tenuata
8. Benthonic foraminiferan Epistominella pacifica
9. Benthonic foraminiferan Uvigerina peregrina
10. Benthonic foraminiferan Bulimina striata mexicana
11. Benthonic foraminiferan Chilostomellina fimbriata
12. Benthonic foraminiferan Cribrostomoides subglobosum
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14. Benthonic foraminiferan Planulina wuellerstorfi
15. Benthonic foraminiferan Reophax horridus
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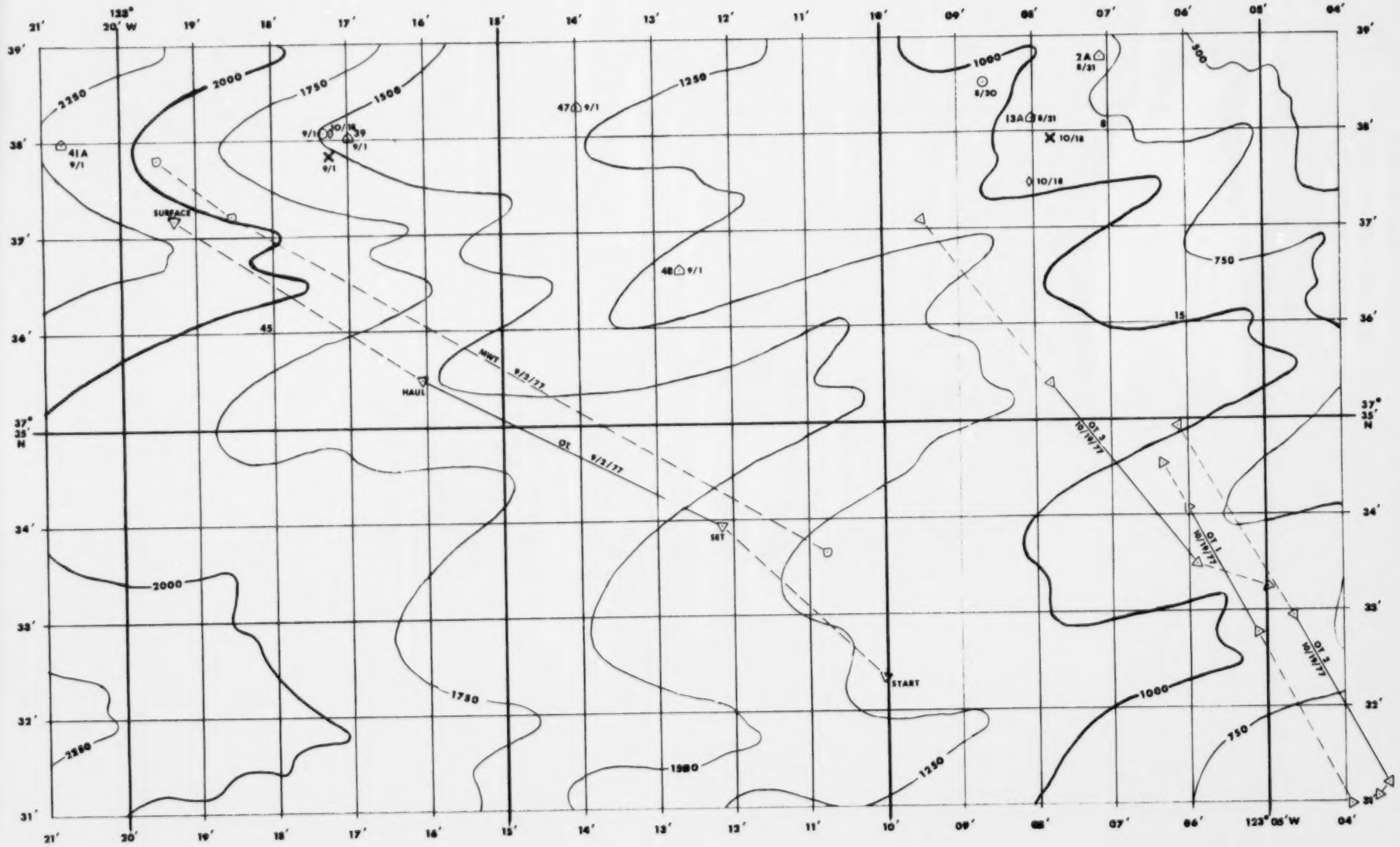

ISOBATH CONTOUR INTERVAL: 250 METERS

0 METERS 5000

M. B. LEWIS - CARTOGRAPHER-IEC

FIGURE 1.

FARALLON ISLANDS RADIOACTIVE WASTE

DISPOSAL SITE STUDY AREA

U. S. ENVIRONMENTAL PROTECTION AGENCY SURVEY

AUGUST - OCTOBER 1977

BOX CORE △ NISKIN CAST ○

STD CAST × WATER SAMPLE ◊

OTTER TRAWL (OT) ▷----▷——▷----

MIDWATER TRAWL (MWT) ○- - - - - - ◇

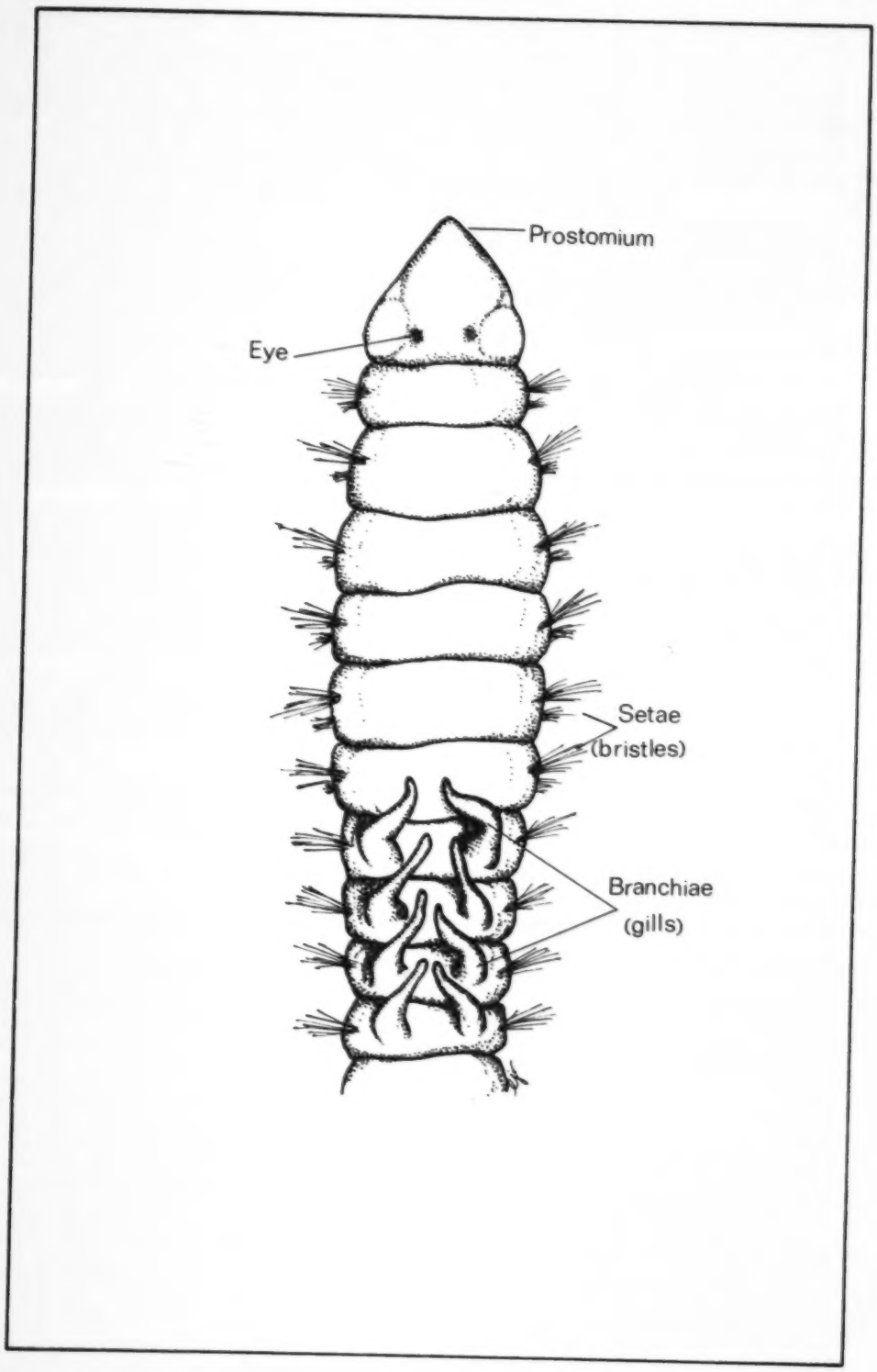

Figure 2. Anterior end of the polychaete Tauberia gracilis

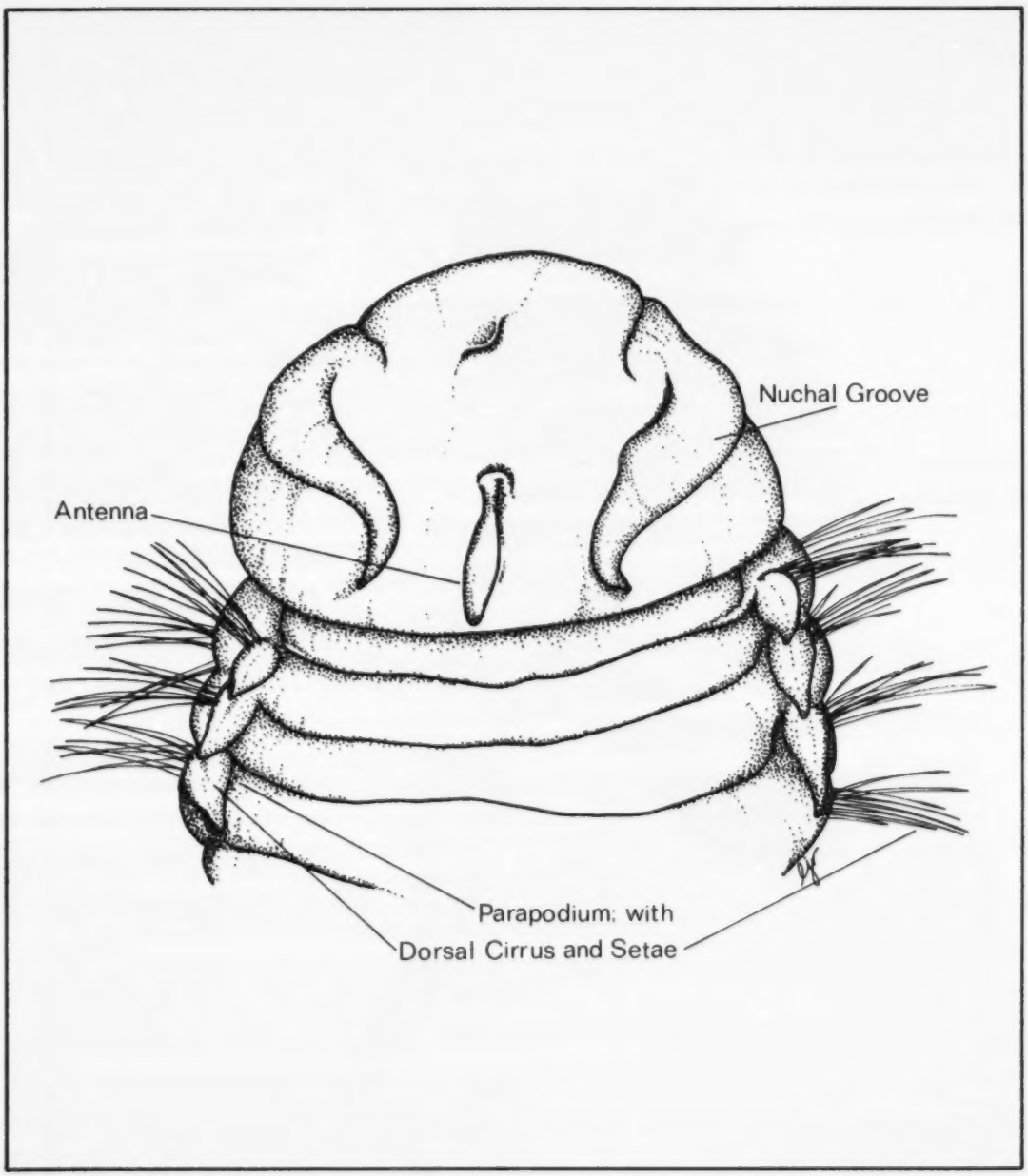

Figure 3. Anterior end of the polychaete Allia pulchra.

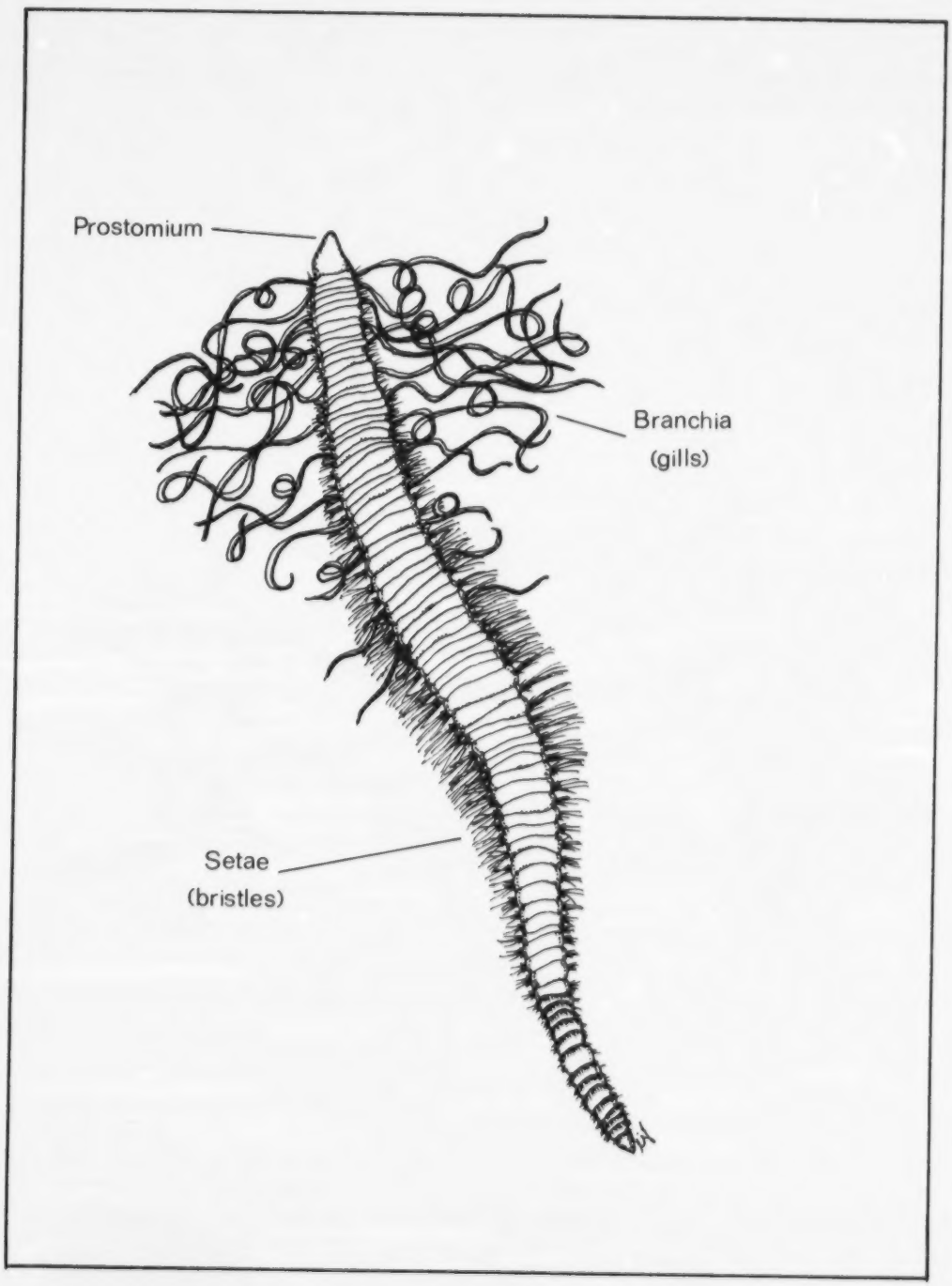

Figure 4. Polychaete Chaetozone setosa

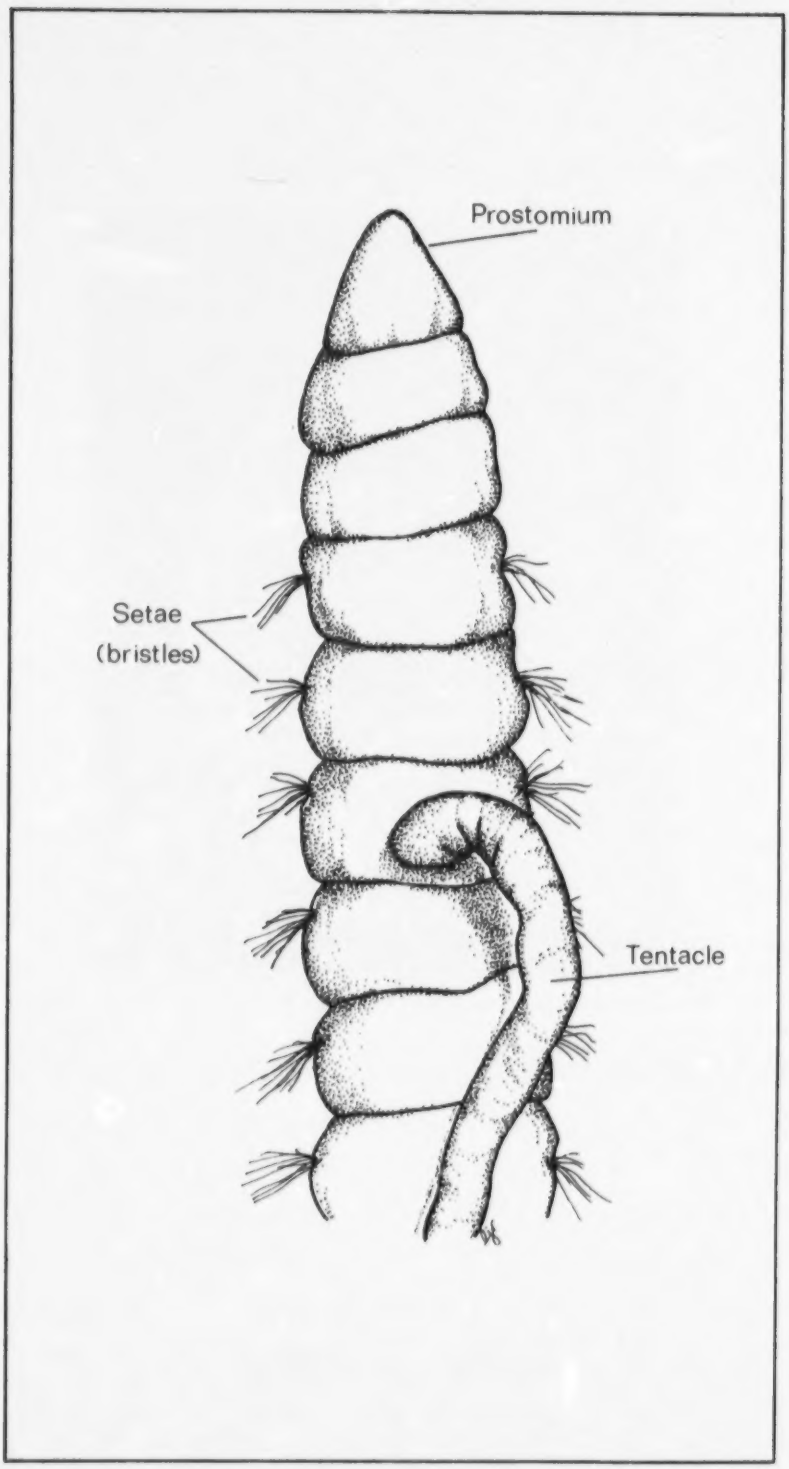

Figure 5. Anterior end of the polychaete Cossura candida.

Figure 6

Bulimina auriculata

(X 104)

Foraminifera

Figure 7

Buliminella tenuata

(X 190)

Foraminifera

Figure 8

Epistominella pacifica

(X 232)

Foraminifera

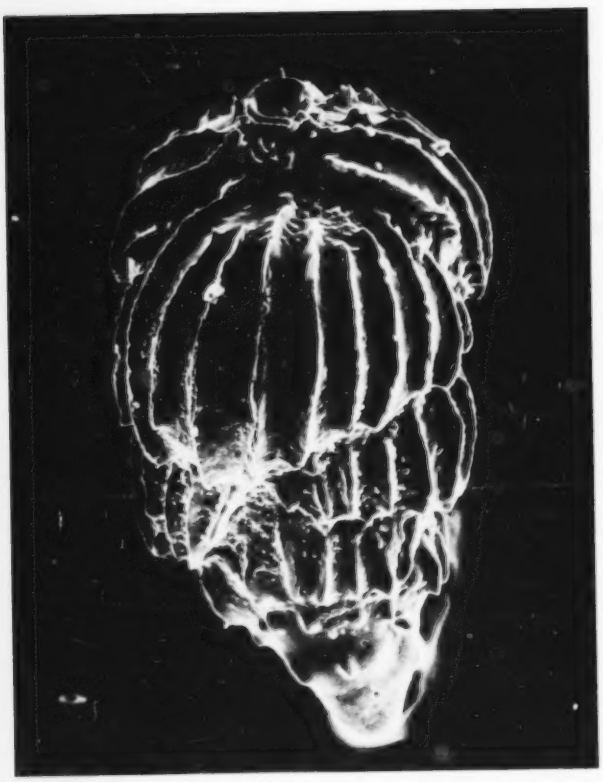

Figure 9

Uvigerina peregrina

(X 149)

Foraminifera

Figure 10

Bulimina striata mexicana

(X 305)

Foraminifera

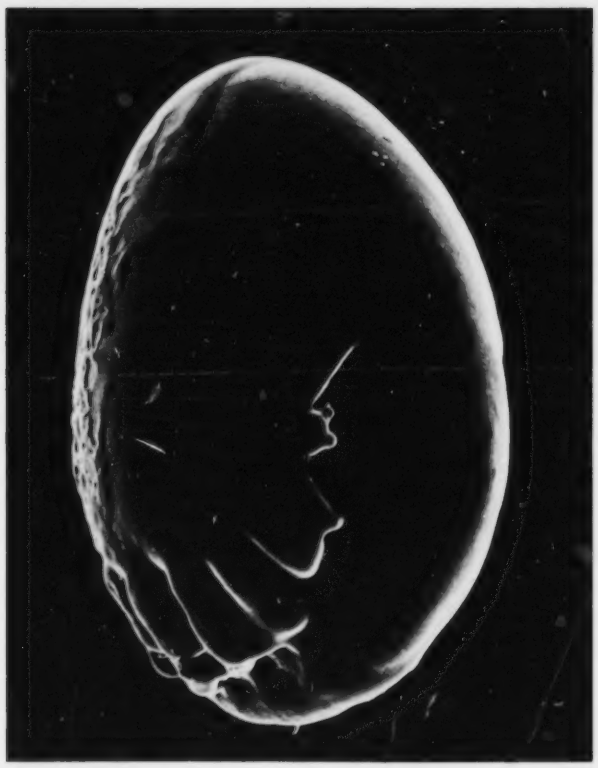

Figure 11

Chilostomellina fimbriata

(X 229)

Foraminifera

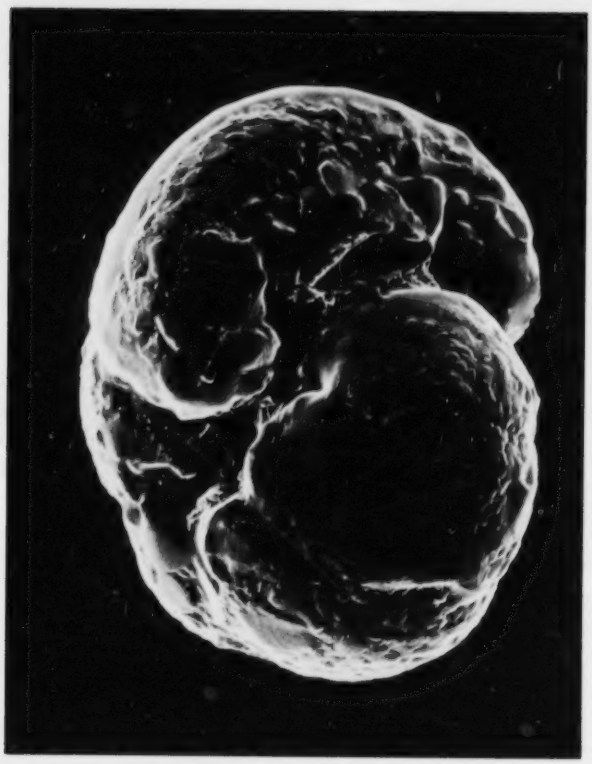

Figure 12

Cribrostomoides subglobosum

(X 126)

Foraminifera

Figure 13

Globobulimina pacifica

(X 162)

Foraminifera

Figure 14

Planulina wuellerstorfi

(X 80)

Foraminifera

Figure 15

Reophax horridus

(X 57)

Foraminifera

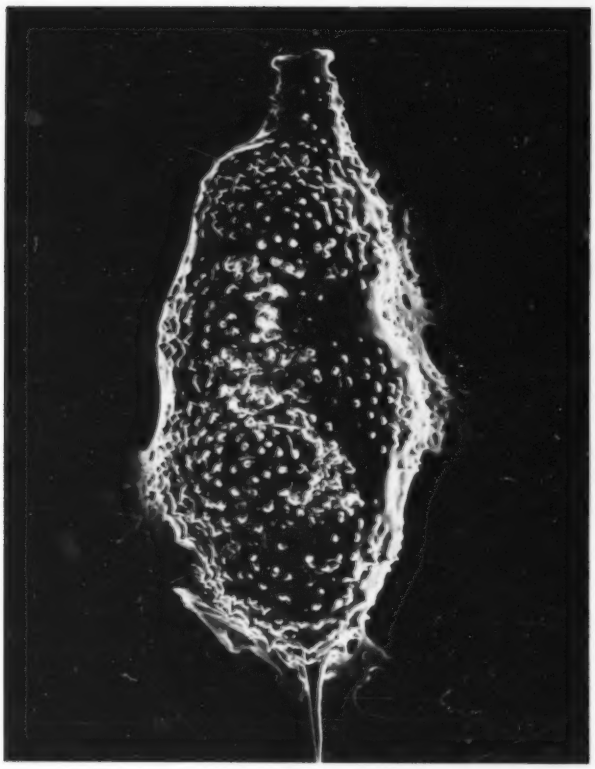

Figure 16

Uvigerina hispida

(X 148)

Foraminifera

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(Please read Instructions on the reverse before completing)

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

Benthic biological samples were taken in 1977 from the vicinity of the Farallon Islands radioactive waste disposal sites for characterization of the infaunal macroinvertebrates and foraminifera. Six quantitative sediment samples were taken with a box core, and two non-quantitative samples were collected with an otter trawl at depths of 900m to 1700m. A sample was also taken from the surface of a radioactive waste container which was recovered from a depth of 730m for subsequent analysis at Brookhaven National Laboratory.

A total of 120 invertebrate species were collected, of which 75 species (63 percent) were polychaetes. Forty-three of these polychaete species have not previously been reported from depths greater than 1000m. A total of 1044 macroinvertebrate specimens were collected of which 54 percent were polychaetes. Only the nematods were present at all six benthic stations, but the community structure was dominated by the polychaetes Tauberia gracilis, Allia pulchra, Chaetozone setosa, and Cossura candida. Living and dead foraminifera were reported. The possible role of polychaetes in bioturbation and in the marine food chain is briefly discussed with respect to the various polychaete feeding mechanisms.

17. KEY WORDS AND DOCUMENT ANALYSIS

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